

AD-A171 446

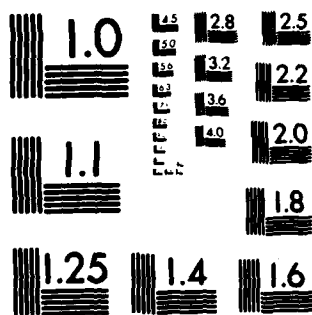
SUPERPOSITIONING OF DIGITAL ELEVATION DATA WITH ANALOG
IMAGERY FOR DATA EDITING (U) ARMY ENGINEER TOPOGRAPHIC
LABS FORT BELVOIR VA R W MAGEL ET AL. 1984 ETL-8-989
P/G 8/2

1/1

UNCLASSIFIED

NL

END
DATE
FILMED
10/26/86
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

AD-A171 446

DTIC FILE COPY

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER USAETL-R-089	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Superpositioning of Digital Elevation Data with Analog Imagery for Data Editing		5. TYPE OF REPORT & PERIOD COVERED
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Randall W. Nagel and Donald M. Camp		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U. S. Army Engineer Topographic Laboratories Fort Belvoir, VA 22060-5546		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS see 10.		12. REPORT DATE
		13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report)
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Photogrammetric Technology Integration Elevation Data Editing Terminal		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The Topographic Developments Laboratory of the U.S. Army Engineer Topographic Laboratories (USAETL) has established the Photogrammetric Technology Integration (PTI) testbed system for the evaluation of superpositioning techniques utilizing electronically scanned hardcopy imagery with overlaid digital elevation data and for the exploitation of new stereoviewing technologies. The testbed is configured around the Elevation Data Editing Terminal (EDET) developed for the Defense Mapping Agency (DMA). The EDET system was designed to anaglyphically display digital elevation data, produced by automated correlation equipment, superimposed on the original imagery allowing an operator to validate or correct		

DTIC
ELECTE
AUG 27 1986
S D

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

the data. Inputs include the original imagery, the setup parameters and digital elevation values. The interior orientation, along with the setup parameters, reestablishes the compilation model. The locally rectified imagery is viewed in one half inch square patches permitting an operator to correct the digital data where necessary. ETL is concerned with the evaluation and enhancements of the EDET system and interfacing new stereoviewing devices as an alternative to the current anaglyphic display.

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

SUPERPOSITIONING OF DIGITAL ELEVATION DATA
WITH ANALOG IMAGERY FOR DATA EDITING

Randall W. Nagel
Donald M. Camp
Topographic Developments Laboratory
U.S. Army Engineer Topographic Laboratories
Fort Belvoir, Virginia 22060-5546

BIOGRAPHICAL SKETCH

Randall Nagel received his B.S. degree in Conservation from Kent State University in 1977 and his M.S. degree in Photogrammetry from Purdue University in 1983. He is currently a Project Engineer with the U.S. Army Engineer Topographic Laboratories (ETL) involved with the engineering development of photogrammetric instrumentation and stereoscopic viewing systems.

Donald Camp received his B.S. degree in Oceanography from George Washington University in 1978 and has completed the graduate coursework for a M.S. degree in Marine Science/Remote Sensing at the University of Delaware. He is currently a Senior Project Engineer with the U.S. Army Engineer Topographic Laboratories (ETL) involved with optical disc technology, stereoscopic viewing systems and development of a filmstrip verification system.

ABSTRACT

The Topographic Developments Laboratory of the U.S. Army Engineer Topographic Laboratories (ETL) has established the Photogrammetric Technology Integration (PTI) testbed system for the evaluation of superpositioning techniques utilizing electronically scanned hardcopy imagery with overlaid digital elevation data and for the exploitation of new stereoviewing technologies. The testbed is configured around the Elevation Data Editing Terminal (EDET) developed for the Defense Mapping Agency (DMA). The EDET system was designed to anaglyphically display digital elevation data, produced by automated correlation equipment, superimposed on the original imagery allowing an operator to validate or correct the data. Inputs include the original imagery, the setup parameters and digital elevation values. The interior orientation, along with the setup parameters, reestablishes the compilation model. The locally rectified imagery is viewed in one half inch square patches permitting an operator to correct the digital data where necessary. ETL is concerned with the evaluation and enhancement of the EDET system and interfacing new stereoviewing devices as an alternative to the current anaglyphic display.

INTRODUCTION

The EDET system was developed under an ETL contract to provide a mechanism for the comparison of digital elevation values against the original stereo imagery by transforming the elevation data matrix to photographic coordinates and superimposing the data as a grid-like pattern of floating dots on the stereo imagery. Two systems were originally fabricated, one was delivered to DMAAC in St. Louis, MO and the other was delivered to DMAHTC in Washington, D.C. The systems were subjected to preliminary testing and evaluation and it became apparent that many problems existed. These included poor resolution and contrast, lack of human engineering considerations, an insufficient light source and the need for an extensive amount of maintenance to keep the systems operational.

ETL received the EDET system from DMAAC in July, 1984 to undergo evaluation and enhancements and to be used as a testbed for the development and evaluation of new stereoviewing devices under the PTI workunit. A three phase development plan was initiated to (1) identify basic system design and engineering deficiencies (2) perform most of the needed enhancements determined necessary in Phase I and (3) continue with the ongoing process of testing and evaluation with DMA and Army requirements taken into consideration when determining project direction.

While testing, evaluation and enhancement of the EDET system is being accomplished, a development effort for an alternative viewing device will be started. The anaglyphic stereo display cannot be viewed in color and can be difficult for an individual to view due to eye fatigue, chromatic aberrations of the eye and reduced brightness and resolution of the projected images (Lillesand and Kiefer, 1979; Farrell and Booth, 1984).

The PTI testbed, and the EDET system in particular, addresses the need to examine, validate and edit digital data as it is incorporated into cartographic, photogrammetric and mapping processes that have been traditionally supported by analog data. This paper will outline the objectives of the PTI workunit as well as describe the configuration, operating procedures and editing capabilities of the EDET system.

SYSTEM OVERVIEW

Configuration

The EDET system is controlled by a Data General Eclipse Ss250 computer with a floating point processor, a 50 Mbyte disc drive, dual 9-track magnetic tape units, a Dasher terminal and keyboard and a control console. The control console is the main interface between the operator and the system. It is made up of a color monitor used for anaglyphic stereoviewing and an operator control panel containing the system control functions. The scanner/stage assemblies each have a glass platen for mounting imagery, a Flying Spot Scanner (FSS), field and objective lenses in the optical path



<input checked="" type="checkbox"/>
<input type="checkbox"/>
<input type="checkbox"/>
Codes
/or

A-1

and a Photo Multiplier Tube (PMT) for light reception and transmission of a video signal. Figure 1 depicts the functional organization of the EDET system (France, Riley and Butson, 1983).

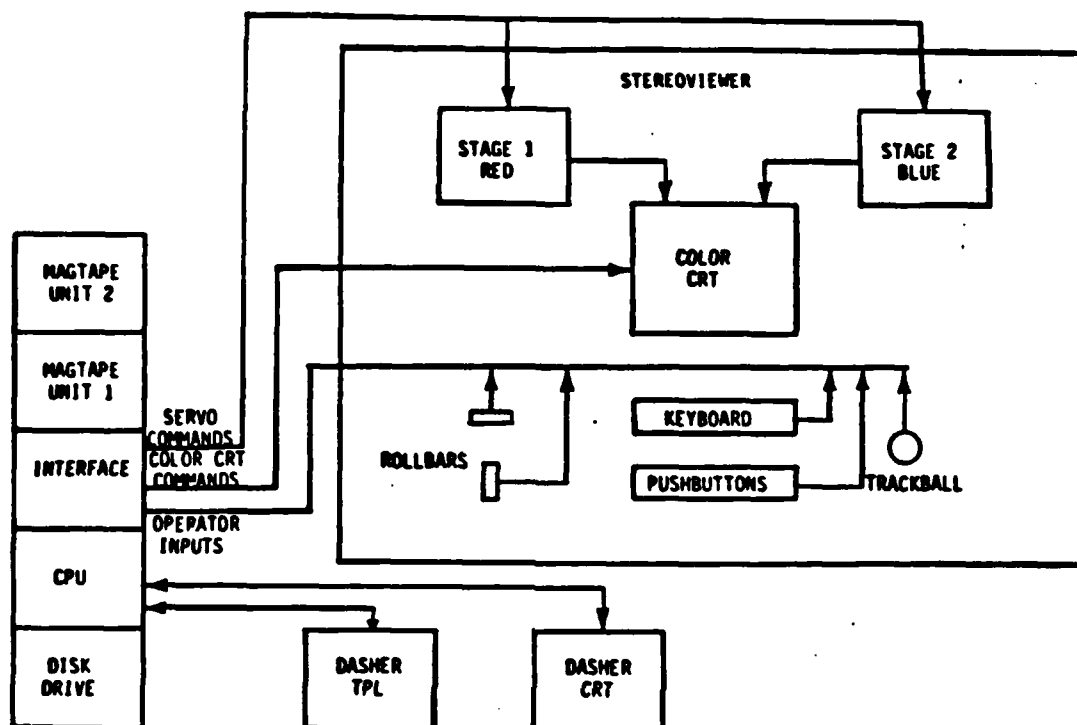


Figure 1. EDET System Functional Overview

Operation

There are three submodes of operation on the EDET system: (1) the calibration mode which provides the capability to calibrate the X and Y stage motions, the scan shaping coefficients and the FSS offsets, (2) the diagnostic mode which provides the capability to diagnose and validate most of the hardware components of the system, and (3) the edit mode which allows an operator to evaluate, validate and correct the digital elevation data.

The necessary procedures required to edit a digital elevation data set are: (1) read the setup parameters and digital elevation values from magnetic tapes, (2) sort the digital elevation data into EDET zones (approximately equal to one half inch patches on the film), (3) perform the interior orientation, (4) validate control points, (5) validate and/or correct digital elevation values, and (6) write the corrected digital elevation models to a magnetic tape or return the model to be recompiled.

The input data consists of a pair of stereo images, setup parameters and digital elevation data that was compiled from the pair of stereo images. The mathematical model and computations are the same as the mathematical model used by the original compilation equipment.

During this procedure the operator is guided through the steps by messages on the console monitor and a series of blinking pushbuttons which indicate possible options or courses of action that can be taken. Only one submode light will blink with the remaining options restricted to decisions within the elected submode.

Editing Capabilities. The operator has four editing capabilities which are: (1) a point edit which allows the correction of an elevation value by "placing" the floating dot on the ground or its removal from the display completely, (2) a segment edit which enables the elevation along an entire line segment to be corrected by a defined delta amount, (3) a sequential edit which allows an operator to step through the dot matrix automatically without using the rollbars or trackball, controlling the viewing speed and editing elevation values when necessary, and (4) the area edit which provides the capability to edit an operator defined polygon by a specified delta amount or to a constant elevation.

The unique advantage of the EDET system is that it allows an operator to qualitatively evaluate the digital elevation data set quickly and accurately in stereo. Due to the large amount of digital data involved, it is often more time efficient to recompile the model than to edit it. The operator can make this decision as he/she scans the model with the elevation matrix superimposed.

DISCUSSION

Unique Development Areas

The EDET system represents ETL's first development effort for DMA directed specifically at allowing superimposition of digital elevation data with the original source photography from which it was compiled. This is viewed as a critical capability to ensure the accuracy of the final digital elevation product. It is especially important in the automated compilation environment, where there is a minimum of man/machine interaction. While the system has not gone into a production mode of operation, it demonstrates the feasibility of the concept and provides technical guidance for future system efforts.

Alternative Approaches. Given the assumption that some sort of closed loop visual verification is required, there are several divergent concepts that may be employed to merge the Digital Terrain Matrix (DTM) with the source photography. Each alternative represents a set of compromises which must be made in terms of speed, resolution, accuracy, cost and the fit within an operational environment.

The simplest solution is to generate a film base matrix of

floating dots from the DTM which can be registered and overlaid with the stereo model. This technique has obvious cost advantages, but requires lengthy processing steps and offers no capability to correct the digital file when an error is found.

At the other extreme is the all digital approach in which digitized or digital imagery is segmented into suitably sized patches, necessary geometric warping and image enhancements are performed, and conjugate pixels are identified and encoded with the DTM value for display on a softcopy stereoviewer. The Digital Image Analysis Laboratory (DIAL) at ETL (Norvelle, 1981) and the Remote Work Processing Facility (RWPF) at DMA are representative of this type of configuration. These systems are used in a research environment where processing speed and cost are not critical factors. They offer substantial flexibility, enabling experienced scientists to develop extraction and display algorithms.

A hybrid solution to the problem of merging analog photography with the corresponding DTM may follow two conceptual approaches. One is to insert a CRT into each optical path of a stereoplotter. This technique has been successfully demonstrated on the Computer Assisted Photo Interpretation Research (CAPIR) system at ETL (Edwards, 1983). A half silvered mirror splits the optical path of an APPS IV analytical plotter, enabling simultaneous viewing of the film transparency and a small CRT. One benefit of this approach is that the image quality of the optical system is preserved. However, distortions inherent in the CRTs are manifested as errors in the elevation model. Additionally, it may be difficult to fuse a matrix of elevation posts distributed throughout the field of view in a convergent stereo pair. A second approach, the one followed in developing the EDET system, is to electronically scan the photographic transparencies and display the video signal in real time on the same CRT that is used to display the DTM.

EDET Scanning System. The electronic scanning of the hardcopy imagery utilized in the EDET system represents a compromise between a typical analytical plotter, with optical binocular viewing, and the all digital systems that are present in the laboratory environment at this time. Inherent are some of the advantages and disadvantages of each type of system. For example, the computer controlled flying spot scanner can correct for anamorphic scale changes, offset, orthogonality, rotation and other distortions in real time. This local rectification allows the operator to view the entire 12.5 mm image patch in acceptable stereo, regardless of image geometry, and permits the accurate transformation and display of a terrain elevation matrix of up to 4000 data points. Slight distortions of the display CRT do not affect height measurements since the DTM and the imagery are subject to identical displacements. The real time requirement for processing hardcopy imagery eliminated the design alternative of complete digital processing of the image data. Thus, there is no capability for enhancement of the image once it is captured by the flying spot scanner assembly.

Further Research

Current efforts in the laboratory are directed at improving the signal to noise ratio to enhance the contrast and viewable resolution. The initial system configuration was based on an image dissector which tracked the image concurrently with the flying spot scanner. This device was replaced by a PMT to improve the light detection capability. Additional modifications were made in the optical components and the electronic circuitry, bringing the system resolution to approximately 32 lp/mm when viewing a 12.5 mm image patch. Further improvements may be obtained by decreasing the line width of the flying spot scanner CRT, improving the noise reduction of the electronics, and ultimately by upgrading the system to 1000 line scanning and display resolution.

- Additional efforts utilizing the EDET system as a testbed involve the development and evaluation of softcopy stereoviewing devices for photogrammetric applications. The anaglyphic display currently being used on the EDET system has the advantage that several observers can view the image simultaneously, however, this type of display is often "uncomfortable" to view for extended periods. As an alternative, a simple device has been constructed utilizing a mirror stereoscope with two small black and white CRTs. The breadboard nature of this viewer severely limits the range of interpupillary distance that can be accommodated, however, the approach will alleviate much of the eyestrain and the chromostereopsis effects of anaglyphic viewing. Development efforts are now focusing on an extended exit pupil optical/CRT viewing device which will provide a greater degree of freedom of head position. An investigation is also underway to develop an autostereoscopic viewing device which will permit unaided viewing by multiple observers.

SUMMARY

The EDET system provides a unique capability for superpositioning DTM data with the source photography from which it was compiled. By viewing a matrix of floating dots on the stereo model, the operator is able to identify and correct errors in the digital data, outputting a revised data tape. The current system is being used as a testbed for the evaluation of this technique, and for the development of softcopy stereoviewing devices that will provide an alternative to the present anaglyphic CRT display.

REFERENCES

Edwards, D.L., 1983, "Terrain Analysis Generation Through Computer-Assisted Photo Interpretation", American Society of Photogrammetry, Technical Papers of the 49th Annual Meeting, Washington, D.C., pp. 152-159.

Farrell, R.J. and Booth, J.M., 1984, Design Handbook for Imagery Interpretation, pp. 5.1-13, Seattle, Boeing Aerospace Company.

France, B., Riley, D. and Butson, P., 1983, Elevation Data Editing Terminal, U.S. Army Engineer Topographic Laboratories, Fort Belvoir, Virginia, ETL-0328.

Lillesand, T.M. and Kiefer, R.W., 1979, Remote Sensing and Image Interpretation, p.319, New York, John Wiley and Sons.

Norvelle, F., 1981, Interactive Digital Correlation Technique for Automatic Compilation of Elevation Data, U.S. Army Engineer Topographic Laboratories, Fort Belvoir, Virginia, AD-A109 145.

FILMED
0=8